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TWO NEW SPECIES OF WEST NORTH AMERICAN MARINE GASTROPODS

BY

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Early in April, 1957, two shells were submitted to me for identification, one by Mrs. C. D. Jennings of Cardiff by the Sea, and the other by Mrs. A. Wolfson of San Diego, California. Information supplied at the time indicated that the specimens were taken alive in about 70 feet of water some time in December, 1956, at the Coronado Islands by Mr. Cecil D. Jennings. It was further stated that they had been heavily encrusted and that each of the two ladies had spent several hours cleaning her specimen.

The two shells undoubtedly belonged to *Astraea*, and more particularly to the subgenus *Uvanilla* (Keen, 1956), but differed from any of the west-coast species known. These facts, together with the information supplied by Mr. Jennings to the effect that the two shells were taken less than two feet from each other, suggested several problems. In an attempt to solve these, a determined effort was made to find the original locality and to obtain additional specimens, including some younger stages. This was done during the month of July, 1957, in cooperation with Dr. E. W. Fager, associate professor of marine biology, Scripps Institution of Oceanography, La Jolla, and his close associate, Mr. Ray Ghelardi. The search comprised a large number of dives made at a great many stations along the shores of

the Coronado Islands which lie off the coast of Lower California. The rich material obtained included at least one new species of marine gastropod and which is described herein, but the sought-for *Astraea* was not found. Through a process of elimination, the log of dives made by Mr. Jennings revealed that one additional locality remained to be explored. This was situated about eight miles southeast from the south tip of South Coronado Island, a place called the "Rockpile" by the divers. This is a submarine plateau, reaching up to about 70 feet below sea level at its higher central area, sloping more or less gradually down to about 110 or 120 feet below sea level at its periphery, and then dropping off rather steeply and suddenly. The plateau is estimated to be about a half mile in diameter. On July 26, 1957, six divers on four successive dives explored this area; Dr. Fager located the third specimen known (our paratype II), crawling among the rocks at a depth of 110 feet. This animal was heavily encrusted, as has been described for the original two (the holotype and paratype I). An attempt was made to bring this new specimen back alive to compare it with living examples of *Astraea undosa* (Wood) and to study it in general; it was placed, therefore, in a live-bait tank aboard the ship, but for unknown reasons did not survive the trip back to base.

On November 19, 1957, Dr. Fager, with four diving companions, again explored the "Rockpile" but limited the search to the higher area of the plateau; this time one young and six adult specimens were obtained. Dr. Fager brought the adult animals by air to Berkeley on November 22. Immediately, upon arrival, they were placed in well aerated aquaria; five of these animals remained alive for from five weeks to two months (paratypes III to VII, below) while the sixth specimen is still living at the time this report is written (January 29, 1958). The young individual was preserved and is not included in the type material of the present study.

The finding of this many individuals, all agreeing very closely, except for small individual variations, conclusively demonstrated that the first two shells are not just chance variants of *Astraea undosa,* but constitute something different. In comparing the shells and their opercula with the type figure of *Astraea petrothauma* Berry, described in 1940, the possibility arose that these shells were living representatives of a species previously known only from its fossil record. This was especially true when the operculum was compared with figure 3 on plate 25 (Berry, *l. c.*). While a comparison of our shells with that of the paratype of *A. petrothauma* in the collection of the Department of Paleontology at Stanford University seemed to show a sufficient number of points of difference between the two, the final decision to consider the animals from the "Rockpile" as members of a heretofore unknown species was arrived at only upon finding still another shell. In

August, 1957, Dr. Wheeler North of Scripps Institution of Oceanography, with a group of assistants, conducted a survey of the kelp beds off the coast of Lower California; at various stations he gathered gastropods for the collection of the Department of Zoology in Berkeley. This material finally reached me in early January, 1958. Among the various lots was one from Sacramento Reef, near Geronimo Island, Lower California, containing a different form of *Astraea,* which agrees so completely with Berry's description, figure, and the paratype at Stanford University, that there is little doubt about its being properly labeled as *A. petrothauma* Berry. This specimen demonstrated clearly enough the differences existing between Berry's and the new species.

After the manuscript for this paper was submitted, but before it could appear in print, one further living member of *Astraea petrothauma* Berry was found. A SCUBA training class, under the supervision of Mr. Conrad Limbaugh, on June 27, 1958, was taken to South Coronado Island. Mr. Limbaugh, being aware of my special interest in *Astraea,* collected 36 young animals, all of which proved to belong to *Astraea undosa* (Wood) except for one specimen. The series of *A. undosa* obtained will be of great value in a planned further study of the entire group of species of this genus occurring on the west coast of North America. But of greater immediate importance was that other specimen. Unfortunately the animal did not survive the trip back to the laboratory, so that still no observations of a living representative of this very interesting species could be made. It seems, however, to add to the conviction that the specimens from the "Rock-pile" are sufficiently different to warrant their being assigned to a new species. The reader is referred to table 3 below for the measurements of this second specimen of *A. petrothauma.*

Astraea (Uvanilla) rupicollina Stohler, new species.

Shell: Large, turbinate (fig. 1), not umbilicated, white, covered with a brown (Maerz and Paul, plate 14, G6)[1], lamellose periostracum; whorls six, rounded, with two distinct carinae of equal prominence on the body whorl, but the upper carina stronger than the peripheral carina on the earlier whorls (fig. 2c); 23 nodules each on both carinae on the body whorl, the 23 oblique, large ribs above the carinae showing a tendency toward dissolving into separate nodules; base rounded, with three distinct concentric corrugations of which the outer is close to the periphery and nearly three

1 Colors were identified, whenever possible, with the aid of the dictionary of color by Maerz and Paul, 1930, and are quoted in a manner which is thought self-explanatory; because of the impossibility of matching colors of small parts of the living snail body with the plates, such colors are given subjective names and are not followed by references to the dictionary.

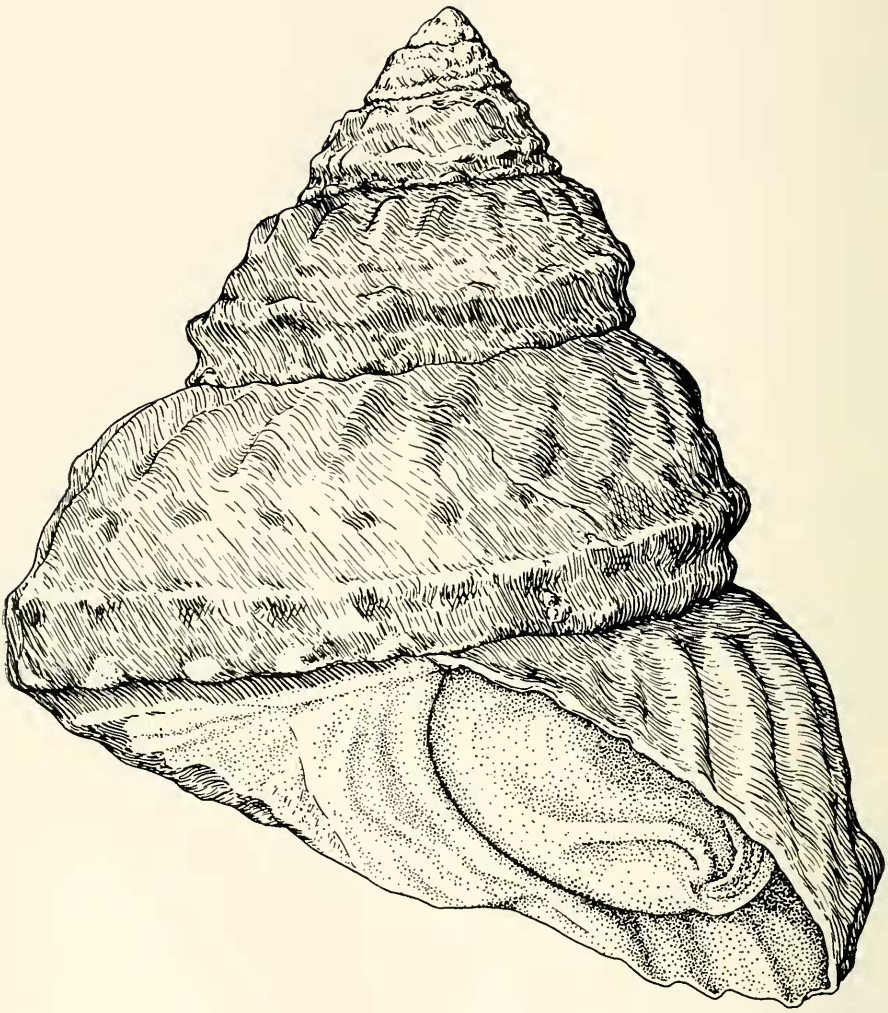

Fig. 1. *Astraea rupicollina*, new species. Front view of holotype showing operculum withdrawn and in its proper position.

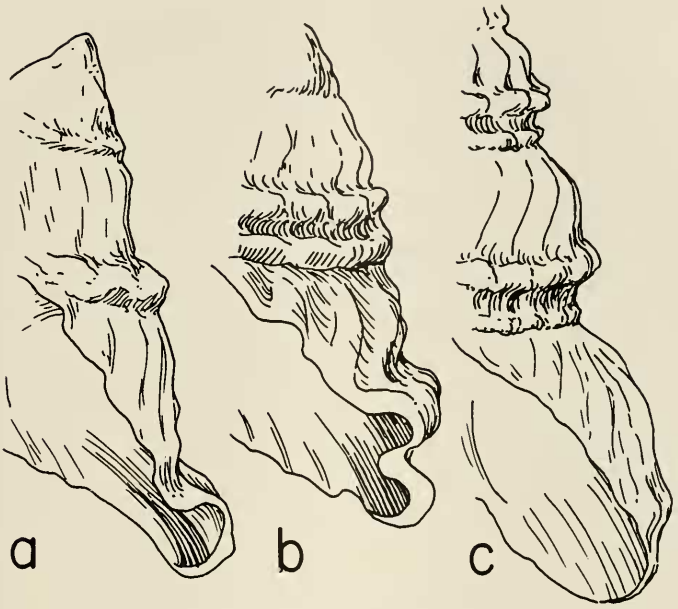

Fig. 2. Outlines of the three species of *Astraea* compared with each other to show the relative strength of the carinae and the fact that the nodules may be hollow or filled in. a = *A. undosa* (Wood) with hollow nodes; b = *A. petrothauma* Berry with hollow nodes and equal carinae; c = *A. rupicollina*, new species, with solid nodes and the secondary carina stronger than the primary one.

times as far distant from the middle corrugation as the latter is from the inner corrugation (fig. 3); there is a faintly perceptible trace of a fourth corrugation about equidistant between the peripheral and the middle corrugation; the peripheral corrugation shows a tendency toward nodulose subdivision; aperture round, outer lip thin, wavy, inner lip heavy, nacreous; inside of aperture pearly; inside of nodules on body whorl not hollow (*cf.* figs. 2a to 2c); columella semicircular, accompanied by a semilunar, fairly deep depression, the outer boundary of which in the umbilical area flattens out into the general callus area, but is produced into a low ridge toward the base of the crescent; still further basally is an additional depression, relatively small and bordered by a heavy, blunt, rounded ridge; a large portion of the base is covered with a thin, nacreous, smooth callus which seems to continue into an advanced incremental area where the periostracum of the shell is dissolved and the fine ribbing of the shell, corresponding to the lamellae of the periostracum, is not yet covered with the new callus material, giving this area a worn appearance; periostracum apparently worn away

Fig. 3. *Astraea rupicollina*, new species. Holotype seen from the base.

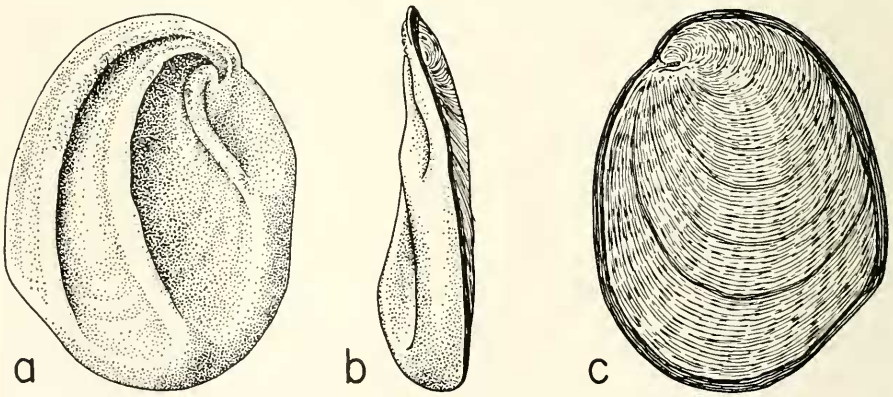

Fig. 4. *Astraea rupicollina*, new species. Operculum of the holotype. a: outside view; b: side view; c: muscle attachment or periostracum side.

on the underside of the first seven to eight nodes of the lower carina and on the peripheral corrugation immediately adjacent to the callus.

OPERCULUM: Heavy, broad-ovate with three spirally curved, prominent ribs (fig. 4), bearing fine pustulate rugosities on the outer surface, rapidly diminishing in number from the nuclear to the distal end of the ribs and lacking completely on the distal five-sixths of the high, median, overhanging rib, as well as on the distal half of the next longest (outer) rib, which is much lower than the median rib; rugosities on the inner rib almost obsolete on the entire length; outer surface of the operculum completely smooth without trace of a lip; nuclear area recurved, tinged with brown; otherwise the outer surface of the operculum is white, shiny; opercular periostracum limited to the flat muscle attachment (inner) side, horny, heavy, sculptured with low, flat, spirally curved ribs and transversely curved, somewhat stronger, more or less concentric incremental ridges; the spiral ribs are noticeable even in the nuclear portion of the operculum; color of the nuclear area reddish brown (Maerz & Paul, plate 6, D 12), the distal portion yellow (M. & P., pl. 10, J 1) with the ribs and incremental ridges a slate blue (M. & P., pl. 48, C 11) (see fig. 5a).

ANIMAL: Approximately the lower half of the sides of the foot is of a predominantly port-wine color (M. & P., pl. 56, J 12), while the upper half is close to red brown (M. & P., pl. 7, H 8); epipodial tentacles four, pure white, short, triangular, gradually diminishing in size from the anterior to the

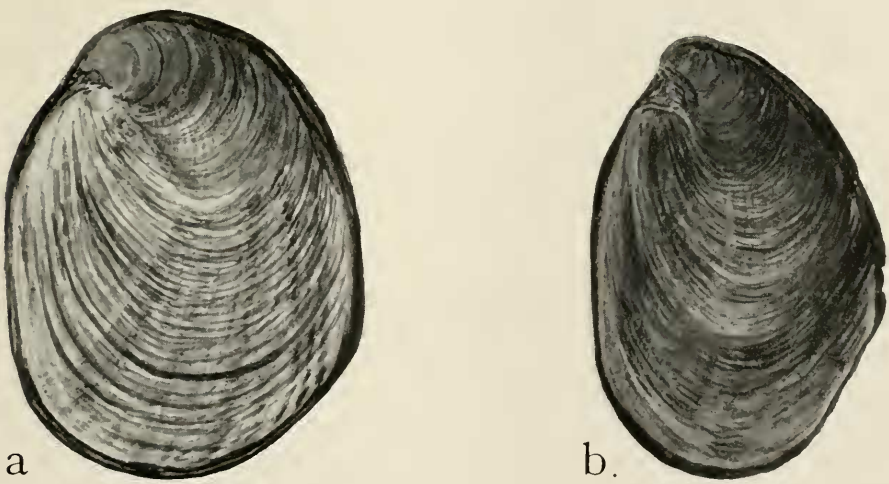

Fig. 5. (a) Operculum of the holotype of *Astraea rupicollina*, new species, showing the periostracum. (b) Operculum of *Astraea undosa* (Wood).

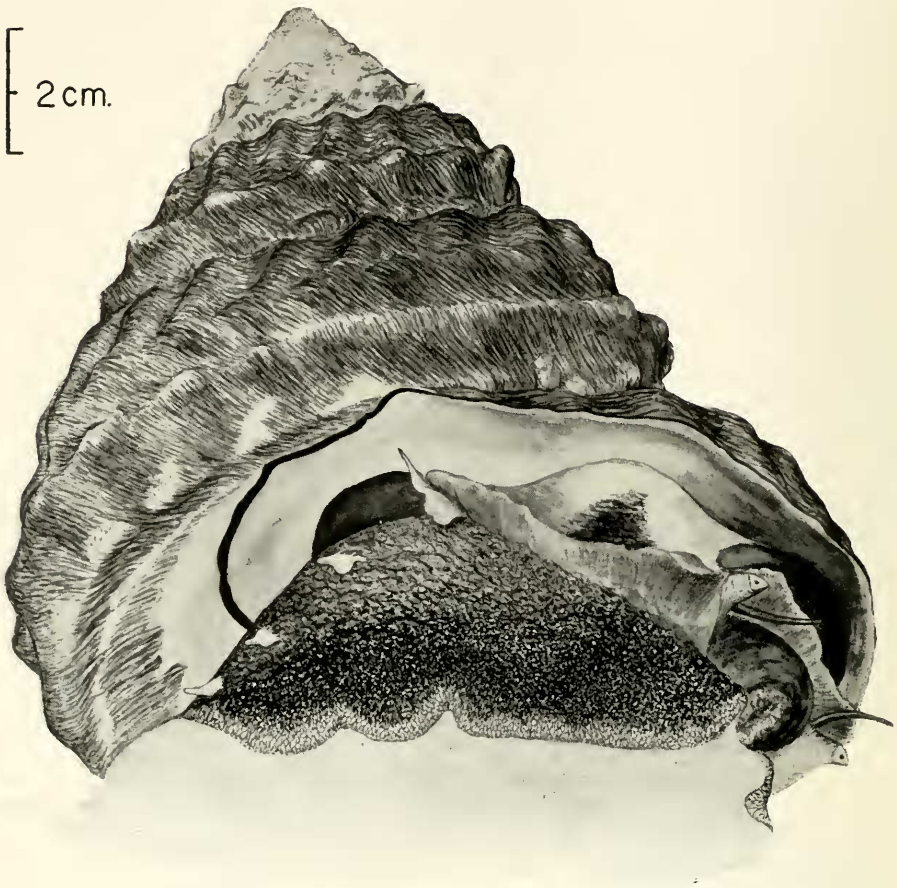

Fig. 6. *Astraea rupicollina*, new species, living animal. Note the four epipodial tentacles. (This is a composite picture, carefully superimposing the cleaned holotype shell upon the heavily encrusted shell of the still living animal, from which the shape and pattern of the soft parts were painted.

posterior end of the row; mantle fold pure white, rimmed with a narrow, jet black margin, which in turn is bordered in the portion lining the aperture by a delicate yellow tinge; the mantle fold also surrounds and partly covers the operculum when the animal is active, outlining the operculum with the jet black margin (see figs. 6 and 7); eyes on prominent, short stalks; tentacles slender, pointed, short, about twice as long as the eye stalks.

RADULA: Broad, flat, long, with four rows of plates; lateral plates each ending in ten short, pointed denticles, median plates in four; a central row of

Fig. 7. Same animal as shown in figure 6 withdrawn into its shell; note the black mantle rim outlining the operculum.

simple, curved ridges separates the median plates; lateral plates heavy, denticles brownish; median plates weaker, denticles lighter brownish; central ridges weak, light ivory colored.

Measurements of the holotype: Greatest height 149 mm.; maximum diameter 134 mm.; height of body whorl 64 mm.; maximum diameter of aperture 71 mm.; angle of divergence 62°; Operculum: greatest length 62.5 mm.; greatest width 47.8 mm.; maximum thickness 16.6 mm.

Paratypes: In addition to the holotype, seven shells are hereby designated as paratypes I to VII; they include the specimen found by Dr. Fager on July 28, 1957 (paratype II), and five of those collected on November 19, 1957 (paratypes III to VII). Not included are the juvenile specimen (although some of its characters will be listed for the sake of completeness) and the still surviving animal as well as a dead shell found even earlier by Mr. Ray Ghelardi at the "Rockpile." Paratype I was the second specimen picked up. It was collected with the holotype by Cecil D. Jennings some time in December, 1956, at what he stated was the same spot as that at which paratype II was found.

To facilitate comparison, the following table lists essential measurements and other observations of the paratypes and of the young animal, and includes the information already given concerning the holotype.

TABLE 1

Comparative data for all the specimens of Astraea rupicollina, *new species, considered in this study.*

	Maximum height of shell, mm.[1]	Maximum diameter of shell, mm.[1]	Height of body whorl, mm.[1]	Maximum diameter of aperture, mm.[1]	Angle of divergence	Corrugations on base[2]					Relative strength of carinae[5]	Tendency to nodulosity[6]	Remarks
						2	3	4	5	6			
Holotype	149	134	64	71	62°	d[3]	d	t[4]	d	d		+	
Paratype													
I	163	139	73	71½	59°	d	d	d	–	d		+	
II	151	135½	63	71½	57°	d	d	–	–	d		+	
III	157½	139	67	72	57°	d	d	–	–	d		+	decollate
IV	156½	138½	67	71½	60°	d	d	–	–	d		+	
V	156½	139	67	76	62°	d	d	–	–	d		+	
VI	139½	120½	58	65	57°	d	d	–	–	d		—	
VII	141½	124½	59	67	56½°	d	d	t		d		—	decollate
Young animal	69	71	33½	37½	61°	d	d	–	–	d		+	denucleate

1. Measurements are to the nearest ½ mm.
2. See figure 8 and the explanation of the diagram for the significance of the numbers.
3. d = distinct, well-developed.
4. t = trace.
5. Relative strength of carinae: no entries in this column since all specimens completely coincide with the conditions described for the holotype.
6. This refers to the tendency of the axial ribs on the whorls to subdivide into nodules; only paratypes VI and VII show complete lack of this tendency.

In general, the paratypes are in excellent agreement with the holotype. Principal differences are that erosion of the periostracum, due probably to the epizoites, is more pronounced in paratypes IV, VI, and VII. Specimens III and VII are slightly decollate, while all others possess the early (excepting the nuclear) whorls, though badly eroded. Only paratype I has four distinct corrugations on the base, while paratype VII agrees completely with the holotype. The others show only the three corrugations which might be des-

ignated as primary, while the faint intercalated fourth corrugation in the holotype and in paratype VII might be called secondary. The opercula of the paratypes seem to offer no points of difference from the holotype or from each other.

TABLE 2

Comparative data for 20 shells of Astraea undosa

Specimen	*Maximum height of shell, mm.*	*Maximum diameter of shell, mm.*	*Height of body whorl, mm.*	*Maximum diameter of aperture, mm.*	*Angle of divergence*	*Corrugations present on base of body whorl*[1]						*Relative strength of secondary carina*[2]	*Tendency to nodulosity*[3]	*Remarks*
						1	*2*	*3*	*4*	*5*	*6*			
a	132½	131½	53	66	72°	–	d	d	d	–	D	+	—	
b	132	132	49½	67½	65°	d	d	d	d	t	–	++	+	
c	129	135	52	66½	66½°	–	d	d	d	D	–	+++	+	decollate
d	127	137	51½	71	74½°	d	D	d	d	d	–	++	+	slightly decollate
e	123	131	52½	66	72½°	–	D	D	D	D	–	++	—	
f	120½	125	48	66	73°	t	D	d	d	–	D	+++	+	
g	118	131	48½	65	79°	d	d	d	–	–	–	—	+	
h	117½	124	46	64	72°	d	d	d	d	–	d	++	+	decollate
i	117	122	47½	64½	60°	d	D	d	d	d	–	++	—	decollate
k	115	127½	51½	65	73½°	d	d	d	–	d	–	+	—	decollate
l	112	135½	48½	67½	73½°	–	–	d	d	d	d	+++	+	
m	112	125	45	64½	71°	t	d	d	d	–	d	++	—	much eroded
n	105	119½	44	61	67°	t	d	D	d	d	T	+++	—	
o	105	118	48½	59½	72°	–	D	D	D	–	d	+++	—	slightly decollate
p	104	115½	43	58½	69°	–	D	d	d	d	–	++	—	
q	100	115½	45	57	71½°	–	D	d	d	d	–	—	+	
r	98½	121½	44	62½	75½°	t	d	d	d	–	d	+	—	
s	94½	108½	38	56	75½°	d	d	d	T	d	t	+++	—	
t	94½	100½	37½	53½	55°	t	D	d	t	–	–	++	+	
u	72½	95½	33½	47½	80°	d	d	d	d	t	–	+	—	

1. T = strong trace; t = trace; D = very distinct; d = distinct; — = absent.

2. The axially aligned nodes of the whorls show a greater or lesser tendency to form secondary smaller nodes; the greatest tendency (*i.e.* the most distinctly subdivided nodes) are indicated with +++, while the complete absence of a subdivision is marked with —; logically ++, and + are intermediates between the two extremes. This column refers only to the first node above the carina, these nodes having a tendency to form what may be called a secondary carina.

3. The tendency toward forming subdivisions in addition to those forming the secondary carina is indicated by a + sign; the — sign indicates that the major nodes show no further subdivision.

TYPE LOCALITY: "Rockpile," approximately eight miles southeast of the southern tip of South Coronado Island, Lower California, Mexico; approximately at 32° 17′ 36″ North Latitude, 117° 09′ 30″ West Longitude; in 70 feet of water; bottom: rocks, rockledges.

The holotype will be deposited in the U. S. National Museum (No. 610, 331); paratypes will be deposited as follows: Stanford University collection (Stanford Univ. Paleo. type collection no. 8644)—paratype I; California Academy of Sciences in San Francisco (Calif. Acad. Sci. Dept. Geol. type collection no. 10471)—paratype II; Academy of Natural Sciences, Philadelphia —paratype III; Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts—paratype IV; Naturhistorisches Museum, Basel, Switzerland—paratype V; British Museum, London—paratype VI; San Diego Natural History Society Museum, San Diego—paratype VII.

The species name is derived from the Latin *rupes* signifying rock and *collis* meaning hill, this being the nearest possible to a literal translation of the local name "Rockpile" of the type locality.

For purposes of comparison a group of 20 shells of *Astraea undosa,* collected on July 21, 1957, off La Jolla Point in 60 feet of water, were measured and the results entered in table 2.

Corresponding measurements of the shells of *Astraea petrothauma* Berry are as follows:

TABLE 3

Corresponding data for the shells of Astraea petrothauma *Berry from Sacramento Reef (A) and from South Coronado Island (B) as well as those taken from the type figure (C) and the type description (D).*

	Maximum height of shell, mm.	*Maximum diameter of shell, mm.*	*Height of body whorl, mm.*	*Maximum diameter of aperture, mm*	*Angle of divergence*	*Corrugations on base of body whorl*						*Relative strength of carinae*	*Tendency to nodulosity*	*Remarks*
						1	*2*	*3*	*4*	*5*	*6*			
A	34.5	48	20.5	24.5	80°	t	d	d	–	D	–	=[2]	—	top eroded
B	40.2	49.3	22.2	25.6	79½°	–	d	d	–	D	–	=	—	top eroded
C					79°							=	—	
D	39.3	49.3	22	26				(4+)[1]						

1. This number is taken from Berry's description of the holotype and attempts to convey that there are four more or less distinct corrugations plus a trace of a fifth one; the relative position of the various corrugations within the scheme shown in fig. 8 cannot be determined.
2. = means that both carinae are equally strong.

To facilitate comparison of the three species in some particular respect, as well as to illustrate the variability within one or the other species in that same respect, a scheme was devised. It is noticed in *Astraea undosa* that the

base of the body whorl may have up to six concentric corrugations. Our figure 8 represents a diagram in which these six possible corrugations are numbered from 1 to 6. C indicates the carina.

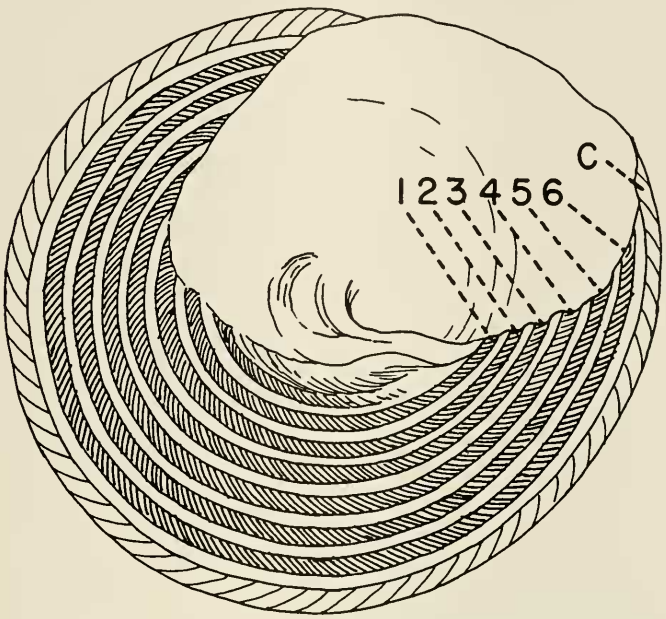

Fig. 8. Diagrammatic representation of the six possible corrugations on the base of *Astraea*, numbered for convenience of reference. C = the carina.

In the tables an attempt is made in column 6 to indicate the position of the corrugations in each specimen as well as to represent in some manner the relative development of each corrugation. If the corrugation is of ordinary or average development, it is assigned a "d" but if it is particularly strongly developed, that fact is indicated by a "D"; a "t" is meant to convey that there is a faint trace of a corrugation discernible, but it may be so faint that only tilting the shell back and forth in oblique light will reveal it; "T" on the other hand, indicates the presence of a readily recognizable trace. Placing the "t" between space 4 and 5 in table 1 was to convey the fact that here the trace is approximately equidistant between the other two corrugations.

Comparison of the Three Living Species of *Astraea*: *Astraea rupicollina* differs from both *A. undosa* (Wood) and *A. petrothauma* Berry by being distinctly higher spired, a much smaller angle of divergence, the rounder aperture, the marked convexity of the whorls, the rounded base of

the body whorl, the number and the arrangement of the corrugations on the base of the body whorl, as well as in details of the sculpture.

Many shells of *A. undosa* examined showed that apparently the nodes, constituting the carina, are laid down first as completely hollow outpocketings of the body whorl; if one examines the inside of the body whorl, it becomes apparent that the animal seems to fill in these empty pockets with nacreous material because, the further inward one proceeds, the less deep are the outpocketings and about one and a half inches from the aperture, the inside of the body whorl appears smooth and devoid of pockets. In our specimens of *A. petrothauma* both carinae show this condition but not one of our *A. rupicollina* shells has a hollow carina, except the young animal, where the lower carina shows an internal fairly shallow and inwardly rapidly diminishing groove; it does not compare at all to the depth of the carinae in the other two species.

The living animal of *Astraea rupicollina* differs from that of *A. undosa* in several features: in the adult of *A. undosa* only the first epipodial tentacle is observed and at that it is difficult to see (fig. 9), while in *A. rupicollina* all four tentacles are very distinct and rather eye-catching because of their contrasting color; the color of the sides of the foot of *A. rupicollina* is essentially

Fig. 9. Living animal of *Astraea undosa* (Wood), showing the mottled pattern of the foot; note the single epipodial tentacle.

two-toned, separated into two more or less distinct parallel areas, while the sides of the foot of *A. undosa* are more or less uniformly mottled and of a much lighter general color, although the dark parts of the mottling are darker (M. and P. pl. 56, A 1) than any of the colors on *A. rupicollina;* the mantle fold in *A. undosa* is not outlined in black around its entire periphery, but is limited to the area outside of the aperture, nor is the yellow tinge present.

No color comparison with *A. petrothauma* was possible as no living specimens were available for study.

There are some differences also in the opercula: The four ribs of the operculum of *Astraea undosa* as well as most of the margin itself are covered with numerous, in part sharply pointed rugosities; they are lacking on the margin opposite the nucleus and on the distal three-fourths of the second rib (numbering the ribs from the basal side up when the operculum is withdrawn into the aperture). In *A. petrothauma* (both specimens, from Sacramento Reef and from South Coronado Island) the first rib is almost entirely smooth, the second has relatively delicate rugosities for about three-fourths of its length, and the third rib has more pronounced rugosities for about seven-eighths of its length. The nucleus of the operculum of *A. rupicollina* appears less spirally recurved than in *A. petrothauma;* of the three ribs the first has few, the second slightly more rugosities, all of which are almost obsolete; on the third rib the sharply pointed pustules extend only for about two-thirds of the length. The margins in both these latter two species are entirely smooth. There are also some differences, though perhaps slight, in the coloration of the periostracum of the opercula. In *A. undosa* the incremental ridges are coarser, while the longitudinal ridges are so faint as to be almost absent (see fig. 5b); the overall effect is much more uniformly dark; in *A. petrothauma* the incremental ridges are distinct, but much finer than in either of the two other species, and the longitudinal ridges are not at all discernible; in *A. rupicollina* the longitudinal ridges are more distinct than in *A. undosa* and are present also in the nepionic portion.

The question arises whether the operculum illustrated by Berry and described as the paratype (*l. c.*, pl. 25, fig. 3) is actually the operculum of the adult *Astraea petrothauma* or, possibly, that of the present species. If the latter were the case, then Berry's name as applied to the operculum would fall into the synonymy of *A. rupicollina,* and the name, *A. petrothauma* would then apply only to the shell described in the same paper. However, I feel that the material at hand is not sufficiently large to warrant a decision at this time; it is hoped that additional specimens of Berry's species, including living animals, may be collected at some future date.

In concluding the discussion of this portion of the present paper, it may be well to consider two other points. It seems, first of all, rather strange that

such a large and magnificent animal as *Astraea rupicollina* has not turned up in dredgings long before this. The nature of the type locality may account for this: because of the large rocks and ledges a dredge, if one were used, might well skim above and over the shells. On the other hand, the manner of the discovery of this species points up the great value of the relatively new research technique employing SCUBA (self contained underwater breathing apparatus). Many exciting discoveries may be expected as this new technique is refined and its application expanded. Secondly, the fact that *A. rupicollina* so far has not been found anywhere else than on the hilltop of the "Rockpile," not even in neighboring areas which were scanned for it during the search in July, 1957, coupled with the fact that *A. undosa* is indeed a highly variable species, may possibly lead, eventually, to the conclusion that we are dealing with an endemic geographical variant of *A. undosa*. It might be further considered possible that *A. petrothauma* is still another subspecies in the *undosa*-Rassenkreis. Until the areas between the "Rockpile" and South Coronado Island in one direction, and between the "Rockpile" and Sacramento Reef in the other, are carefully and minutely explored, it seems advisable to consider all three forms as good species. And since no specimens of *A. undosa* were obtained at the "Rockpile" or anywhere nearer to it than at the south tip of South Coronado Island, approximately 8 miles to the northwest, coupled with the fact that no tendency toward the *A. rupicollina* or *A. petrothauma* shape could be observed in the many examples of *A. undosa* examined, the idea that we are indeed dealing with a heretofore unknown species seems to gain plausibility.

The fact that a living specimen of *Astraea petrothauma* Berry was found very recently at South Coronado Island, does not, it would seem, detract from the validity of this conclusion; it adds, however, to the problem of distribution of Berry's species. Originally it was not deemed worthy to note that the specimen of *A. petrothauma* from Sacramento Reef was taken in less than 30 feet of water. Since, however, the second specimen at South Coronado Island was also taken in relatively shallow water (between 10 and 50 feet, according to Mr. Limbaugh, although the exact depth where the specimen in question was picked up, is unknown), and since, on the other hand, all of the known specimens of *A. rupicollina* come from depths in excess of 70 feet, it now seems proper to record these facts.

Comparison with *Astraea gradata* Grant & Gale:

In comparing *Astraea rupicollina* with the fossil species from the middle Pliocene, described in 1931 by Grant and Gale as *A. gradata*, several points of difference are readily noticeable. The material used for this purpose consisted, in addition to the excellent illustrations of the type material in Grant & Gale, plate 31, of two topotypical specimens from the collection of the

Museum of Paleontology at the University of California, kindly made available to me by Dr. J. W. Durham.

In *Astraea gradata* the upper of the two parallel carinae is much less fully developed, especially on the early whorls, than in the new species. The nodes on the whorls are raised more and turn in at almost a right angle toward the suture, thus giving the fossil species that more or less tabulated aspect which led the authors to choose the name; in *A. rupicollina* the nodes appear more or less parallel in their entire length to the convexity of the whorl. There are three basal corrugations in *A. gradata,* equally distributed over the entire basal area, not leaving room for a possible undeveloped fourth or even fifth corrugation, a condition clearly present in *A. rupicollina* (see the comparison above with *A. undosa*). Even more striking are the differences in the opercula. That of *A. gradata* is sub-circular and seems to have only two ribs, although there is a broad, very flat, low protuberance, possibly a rudiment of the (for the subgenus *Uvanilla*) typical third, basal rib. While the middle rib of *A. rupicollina* is thin, high, and overhanging, that of *A. gradata* is flat, shallow, and broad. The area between the two basal ribs in *A. gradata* appears to be covered with fairly numerous, fine pustules, whereas the corresponding area in *A. rupicollina* is polished. Finally, the nuclear whorl of the operculum is much less recurved in *A. gradata* than it is in the new species.

In spite of the many differences between the two species, it seems possible that *Astraea rupicollina* may prove to be a more or less direct linear descendant of *A. gradata.* Much more fossil material of the latter and some very young stages of the former species will be needed before this question can be answered satisfactorily.

Macrarene coronadensis Stohler, new species.

As mentioned above, in the search for the new astraea, a number of stations around the Coronado Islands were closely examined by Dr. Fager and his associates during July, 1957. Only a few hundred feet seaward from the North Island they found six specimens of a species belonging to the genus *Macrarene* (Hertlein and Strong, 1951). The same species was taken on three different dives one week later at the "Rockpile"; on November 19, 1957, Dr. Fager picked up one living and one dead specimen, again at the "Rockpile." Depths of collections varied from 150 feet to 70 feet.

The shells did not agree with the three other species of the genus, found in California waters, i. e., *Macrarene pacis* (Dall), *M. californica* (Dall), and *M. farallonensis* (A. G. Smith). The rich material in the collections of the San Diego Society of Natural History and of the California Academy of

Sciences was minutely compared before it was decided to consider this a new species.

For the description it became necessary to compile the characters from three shells (one of which is designated the holotype and the other two paratype I and II respectively) because all shells are more or less completely covered with encrusting organisms and because it proved impossible to remove this encrustation without possibly damaging the finer sculpture of the shell, at least in part.

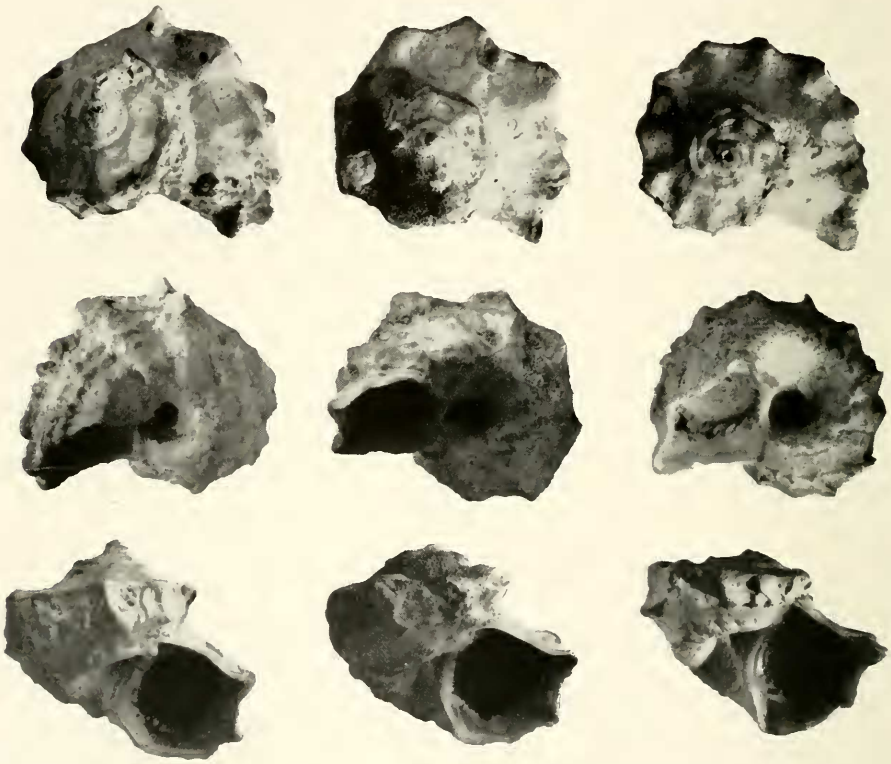

Fig. 10. *Macrarene coronadensis*, new species. Holotype and paratypes I and II. Top row: apical view of the three specimens; middle row: the same three specimens seen from the umbilicus; bottom row: lateral view. The first picture in each row is of the holotype; the second of paratype I and the third of paratype II. NOTE: On the holotype may be noted a peculiar, extremely hard encrustation surmounting the apex and giving it a somewhat higher aspect than it is in reality. Photographs by Victor Duran.

Shell: Large for the genus, heavy, tabulated, with three and a half to four whorls, nacreous-white; periphery of whorls angular with 9 to 12 projections on the body whorl and the preceding whorl; tabulated area above the projections smooth, unsculptured except for very faint undulations coinciding with the projections. Whorls rapidly enlarging with distinct sutures; aperture circular within, shiny, pearly; outer margin of aperture flaring, with five corners, best described as a square to the base of which is fused an isosceles triangle. The whorls are angular in outline; this outline is produced by the relatively sharply pointed, subequally spaced, short projections of the periphery; the projections are connected with fairly distinct ridges producing the effect of a continuous carina. Parallel to the peripheral carina and below it is a second carina, equally strong and consisting of the same elements, *i. e.*, projections and connecting ridges. The projections of the two carinae are connected with each other by oblique, somewhat folded-over ridges which divide the otherwise smooth lateral area of the whorl into subequal parallelograms. Below the lower carina the body whorl slants toward a narrow, rounded base. In addition to the faint ridge-like oblique swellings corresponding to the projections above, there is on this portion of the body whorl a pair of spiral cords, very closely situated to each other and about equidistant between the lower carina and the base of the whorl. The umbilicus is very wide, deep, spiral with a distinct keel spiraling down and ending on the inner base of the isosceles triangle. Whorl ending obliquely (see fig. 10).

Operculum: Horny, with numerous, fine, concentric rings of ridges (this is very reminiscent of the operculum of *Norrisia norrisi* (Sowerby), except that the rings are so fine that they are discernible only under magnification); there is a fringe of fine strands of horny substance around the periphery; the shallowly concave operculum seems to fit "airtight" over the inner aperture.

Animal: Sides of the foot brown; foot narrow, fairly long, about two and a half times as long as broad; tentacles filiform.

Holotype measurements: Maximum height 18.6 mm.; max. diam. 22.3 mm.; body whorl height 11.4 mm.; diam. of aperture 6.1 mm.; angle of divergence 122°.

Measurements of paratypes I and II: I. Max. height 18.7 mm.; max. diam. 22.4 mm.; height of body whorl 12.0 mm.; diam. of aperture 6.3 mm.; angle of div. 128°. II. Max. height 15.8 mm.; max. diam. 22.7 mm.; height of body whorl 11.6 mm.; diam. of aperture 6.5 mm.; angle of div. 140½°.

Type locality: Seaward side of North Island of the Coronado Islands, Lower California, a few hundred feet from shore in 150 feet; bottom: large rocks, ledges, sand pockets. This locality is at about 32° 27′ North Latitude and 117° 11′ 45″ West Longitude.

In table 4 are recorded the measurements of all 25 specimens collected alive in the two areas described above (for comparison the measurements of the holotype and paratypes I and II are also entered in the table).

TABLE 4

Comparative data for all 25 specimens of Macrarene coronadensis, *new species.*

	Maximum height, mm.	*Maximum diameter, mm.*	*Height of body whorls, mm.*	*Diameter of aper. where it is circular, mm.*	*Angle of divergence*	*No. of projections on body whorl*	*No. of whorls*	*Remarks*
Holotype	18.6	22.3	11.4	6.1	122°	9	4	
Paratype I	18.7	22.4	12.0	6.3	128°	9	4	
II	15.8	22.7	11.6	6.5	140½°	12	3½	
III	18.2	23.0	11.0	6.0	118°	10	?	heavily encrusted
IV	18.9	22.2	11.5	5.4	106½°	10	?	heavily encrusted
V	22.2	26.6	12.5	7.2	110°	10	4?	nepionic whorls encrusted
Hypotype I	19.1	24.4	12.4	6.3	109½°	9	3½	
II	19.5	23.2	12.0	7.1	119½°	10	?	heavily encrusted
III	16.9	22.0	11.5	6.8	123°	11	3½	
IV	20.8	24.1	12.1	7.0	123°	11	3½	
V	20.8	23.6	11.4	6.3	126½°	10	?	heavily encrusted
VI	19.2	24.5	12.6	6.4	130°	10	3½	
VII	20.3	25.3	12.9	7.3	130°	9	4	
VIII	19.8	25.3	11.9	6.1	130°	9	4	
IX	20.7	24.0	12.3	6.2	126°	10	?	heavily encrusted
X	20.2	22.4	10.9	6.1	126°	10	4	
XI	18.4	23.0	12.2	6.1	123½°	9	?	heavily encrusted
XII	18.8	20.9	11.3	5.8	124°	10	3½	
XIII	16.8	21.1	11.6	6.0	134°	10	3½	
XIV	15.3	20.0	11.2	5.5	136°	7	3	
XV	23.2	26.9	13.6	7.4	134½°	9	4	
XVI	20.2	25.7	12.0	6.6	138°	8	?	heavily encrusted
XVII	18.3	25.9	12.9	7.3	132½°	7	3½	
XVIII	14.6	19.8	11.0	4.9	140½°	8	?	heavily encrusted
XIX	21.6	22.3	11.0	5.4	121½°	9	3	

The specimens collected at the "Rockpile" are designated as hypotypes I to XIX.

DISPOSITION OF TYPES: The holotype and paratypes I and II will be deposited in the U. S. National Museum in Washington, where they will be assigned the numbers 610,332 (holotype) and 610,333 (paratypes). Paratype III will be deposited at Stanford University (Stanford Univ. Paleo. type coll. no. 8645); paratype IV will go to the California Academy of Sciences (Calif. Acad. Sci. Dept. Geol. type coll. no. 10506); paratype V

will be sent to the British Museum in London. Of the many hypotypes, one each will be deposited with the Academy of Natural Sciences, Philadelphia; Museum of Comparative Zoology, Harvard University; Naturhistorisches Museum Basel, Switzerland; and the San Diego Natural History Society Museum in San Diego. The remaining hypotypes will be retained, at least for the time being, in the collection of the Department of Zoology at the University of California in Berkeley.

Comparison: *Macrarene coronadensis* appears to be larger than any of the three other species of this genus known from California waters. It has more projections on the periphery of the body whorl than either of the two Dall species *(M. pacis* and *M. californica)* and generally fewer than the third species, *M. farallonensis.* It bears the greatest affinity to *M. pacis* but is easily distinguished from it by the possession of the second row of projections below the periphery. In both species described by Dall the projections at the periphery are curved upward, while in *M. coronadensis* they project horizontally. From *M. farallonensis* the new species is easily distinguished by the absence of the pronounced axial sculpture on the basal portion of the body whorl as well as by the smoothness of the relatively level upper surface of the body whorl. Because of these marked differences a rather simple key may serve to separate the four species now known.

Key to the California Species of Macrarene

1. Projections at the periphery of the body whorl six, blunt, rounded ..... *M. californica* (Dall)
— Projections at the periphery of the body whorl more than six 2
2. Only one row of projections on the body whorl, not exceeding eight in number ..... *M. pacis* (Dall)
— Body whorl with more than eight projections or with two parallel rows of projections 3
3. Body whorl with two distinct, equally strong parallel rows of projections; 7 to 12 projections per row (usually 9 or 10); projections not pointing upward; upper surface of whorls rather smooth ..... *M. coronadensis* Stohler
— Body whorl sculptured with strong axial oblique ribs extending from suture to base ..... *M. farallonensis* (A. G. Smith)

Remarks: There has been much discussion regarding the correct generic name for this group of shells; Smith in 1952 gave a brief, yet excellent summary of this problem. However, I feel that the generic name proposed by Hertlein and Strong in 1951 really beautifully and simply solves the problem and I have adopted that name for those reasons.

It seems fitting to close this paper with an expression of appreciation for the generous cooperation shown by so many people, without which these two species might have remained unknown still longer. The roles of Dr.

E. W. Fager and R. J. Ghelardi, as well as those of Mr. and Mrs. C. D. Jennings and Mrs. Alan H. Wolfson have been mentioned. In addition to these contributions, credit belongs also to C. M. Boyd, T. K. Chamberlain, W. D. Clarke, H. L. Scotten, and J. R. Stewart, graduate students at Scripps Institution of Oceanography at La Jolla for spending much time in diving and helping in the search; Mr. C. Limbaugh, the marine diving specialist of the same institution also participated in the collecting; without the good-natured accommodations of Mr. D. A. Noland, the skipper of the buoy boat used, the search would probably not have been successful. Drs. A. M. Keen of Stanford University and Leo G. Hertlein of the California Academy of Sciences generously made the collections under their curatorship available to me. Dr. Cadet Hand of the Department of Zoology, University of California, kindly read the manuscript. The figures owe their excellence to the great skill of the staff artist, Mrs. Emily Reid.

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